APPENDIX C

THRUST BLOCKING

C-1. Magnitudes of thrusts. Thrusts on pipelines with unrestrained joints occur wherever a branch outlet or a change of alinement exists. Thrust forces can be large and may cause the movement and rupture of an inadequately anchored distribution main with unrestrained joints. If the lengths of pipe are joined by tension joints, such as welded joints in a steel pipeline and lugged joints in concrete and cast-iron pipelines, other forms of anchorage are not usually required. The determination of whether or not a given section of pipeline needs thrust blocks or other means of anchorage should be made by a qualified engineer. All thrust anchorages will be designed for a safety factor of not less than 1.50 under maximum pressure loading. The magnitude of hydrostatic thrust may be determined by the following equation:

Thrust at bend: $T_A = 2\pi r^2 p \sin \Delta/2$

where:

T = thrust in pounds
r = radius of pipe joint in inches
p = water pressure in lb/in^2
Δ = bend deflection angle

Thrust at dead end or branch: $T_E = \pi r^2 p$; where T_E is thrust in pounds. Nomographs for the determination of thrusts are given in figures C-1 and C-2. The insets on these figures illustrate how the nomographs are to be used. For example, if the water in a 16-inch pipe is at a pressure of 100 psi, the thrust at a dead end on this pipe is 20.1 kips (a kip is equal to 1,000 pounds). This is obtained by drawing a straight line from the 100-psi value on the "P" column to the 16-inch value on the "D" column. This line crosses the "T_E" column at the resultant value of the end thrust. If this same pipe made a 45-degree bend, the thrust at the bend is determined by drawing a straight line from the 20.1-kip value on the "T_E" column to the 45-degree value on the "Δ" column. The point at which this line intersects the "T_A" column, 15.4 kips, is the value of the thrust at the bend. Detailed thrust block design can be obtained from the CIPRA Handbook of Ductile Iron Pipe Cast Iron Pipe.

C-2. Anchorage of horizontal thrusts.

a. Bends which do not require anchorage. Small horizontal bends formed by deflection of pipe joints, or by beveling pipe joints, often do not require anchorage against thrust. The maximum deflection angle which does not require some form of anchorage is given by the following equation:

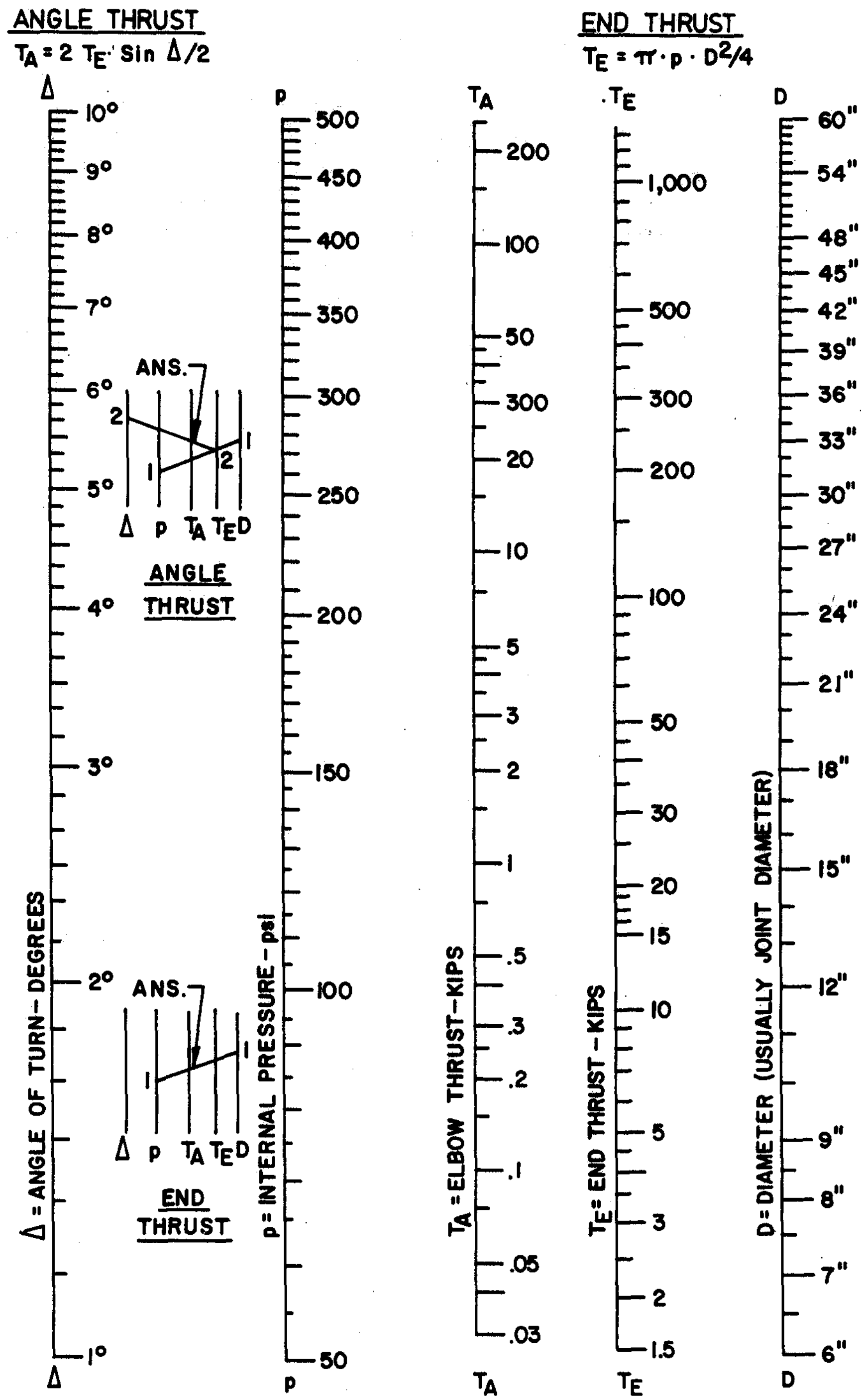

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FIGURE C-1. THRUSTS AT BENDS (LESS THAN 10 DEGREES) AND ENDS

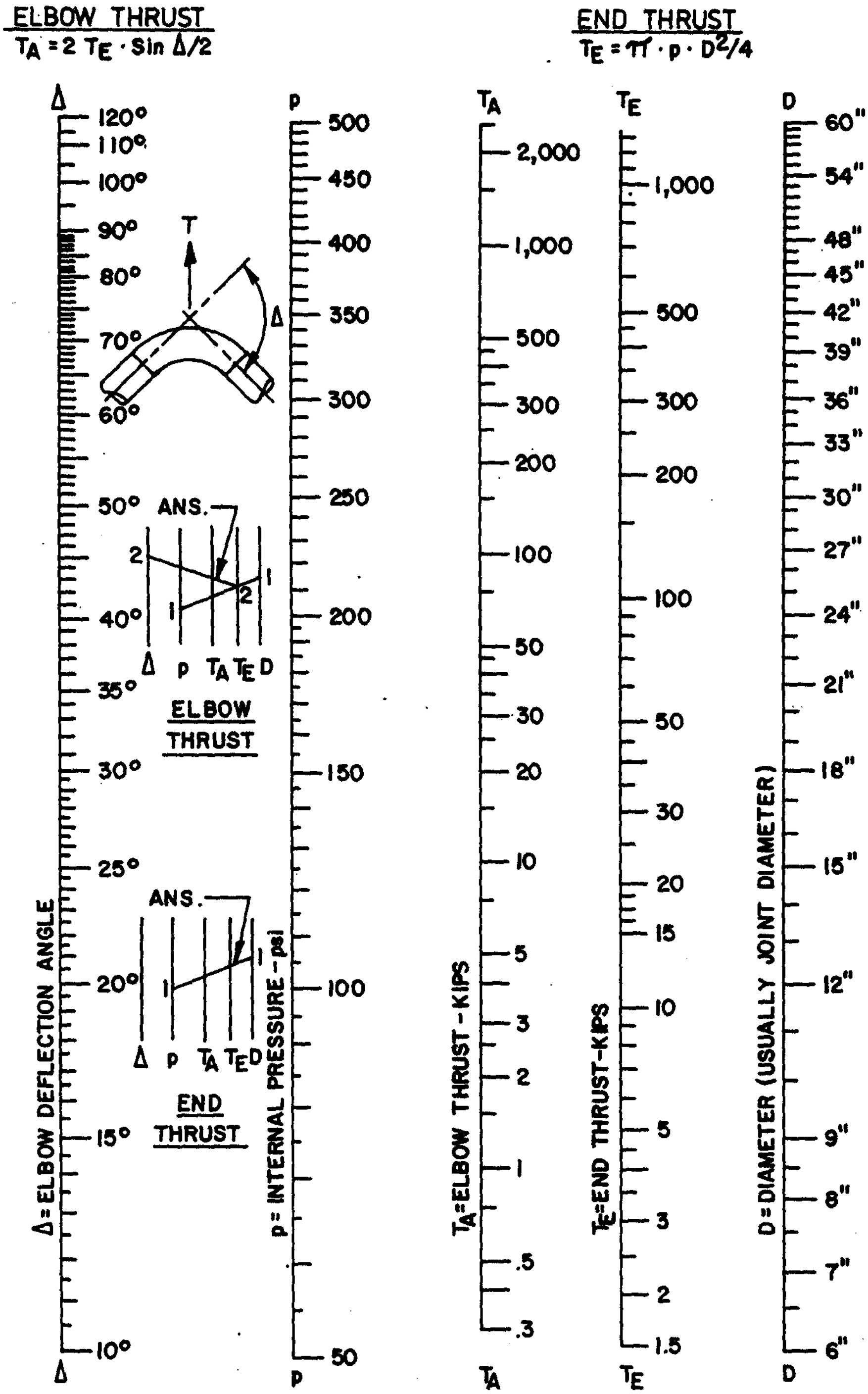

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FIGURE C-2. THRUSTS AT BENDS (GREATER THAN 10 DEGREES) AND ENDS

$$\Delta = 2 \tan^{-1} \frac{Wf}{(2\pi r^2 p)}$$

where:

Δ = maximum deflection angle
W = the combined weight of each pipe adjacent to the bend, the water in the pipe, and the soil over the pipe
f = the coefficient of friction between the pipe and the soil beneath

b. Types of anchorage. Either thrust blocks or frictional thrust anchorage may be used for bends requiring thrust anchorage. Blocks for horizontal thrusts must be poured against firm, undisturbed soil, and the bearing surface should be as nearly vertical as possible. In designing friction thrust anchorages, credit may be taken for the combined weight of the pipe, water in the pipe, and soil above the pipe in calculating the length of tied pipe necessary to develop frictional resistance to counteract the thrust.

C-3. Anchorage of vertical thrusts.

a. Bends which do not require anchorage. The maximum vertical deflection angle not requring some form of anchorage is given by the following equation:

$$\Delta = 2 \tan^{-1} \frac{(w \cos \theta)}{2\pi r^2 p}$$

where, assuming that water is flowing from pipe "a" to pipe "b":

Δ = the angle of deflection of the centerline of pipe "b" from the centerline of pipe "a"
θ = the angle of deflection of pipe "a" from the horizontal

In addition, the beam strength of the pipe must be adequate to safely carry the assumed loads; if it is not, the thrust at the bend should be anchored with a concrete reaction block.

b. Anchorage with reaction blocks. Bends larger than those determined by the above formula can be anchored by a reaction block poured around the bend or poured below and strapped around the bend.

C-4. Anchorage at valves and reducers. Provisions should be made to anchor longitudinal thrust against a closed valve, unless it can be absorbed by compression along the pipeline. Anchorage is normally not required for buried valves on concrete pipelines or on steel pipelines with welded joints, unless the valve is at or near the end of a buried concrete pipeline. Pipelines having joints which do not absorb compressive thrusts, such as some types of rubber-gasketed joints, should be supplied with some form of anchorage for valves and reducers. Suitable forms of anchorage include thrust collars poured around the pipe adjacent to the valve with the anchored pipe tied to the valve, or anchorage of the valve to the structural valve vault in which it might be enclosed.